MEASURING THE DEGREE OF MIXING IN A STACK OR DUCT USING AEROSOLS AND TRACER GAS

Purpose

This Meteorology and Air Quality Group (MAQ) procedure describes the process to determine the degree of mixing in exhaust stacks and ducts using a surrogate aerosol and a tracer gas at proposed sampling locations to determine if single point sampling using the shrouded probe technology can be used.

Scope

This procedure is used to perform aerosol and tracer gas studies in exhaust stacks and ducts to determine the suitability of the proposed sampling location for single point sampling. MAQ-121, “Sampling/Monitoring Radioactive Particulates, Tritium and Gases From Exhaust Stacks, Vents, and Ducts” dictates when to use this procedure and how to apply the results.

In this procedure

See page 2 for Table of Contents.

Hazard Control Plan

The hazard evaluation associated with this work is documented in Attachment 1: Initial risk = **low**. Residual risk = **low**. Work permits required: Radiation Work Permits, facility-specific permits. First authorization review date is one year from group leader signature below; subsequent authorizations are on file.

Signatures

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General information about this procedure

In this procedure

Attachments

This procedure has the following attachments:

Number	Attachment Title	No. of pages
1	Hazard Control Plan	3
2	MET One Performance Verification form example	1
3	Aerosol Measurement Location, Setup, and Results	2
4	Tracer Gas Measurement Location, Setup, and Results	2
5	Tracer Gas Raw Data Input Form	1

History of revision

This table lists the revision history and effective dates of this procedure.

Revision	Date	Description Of Changes
0	11/27/96	New procedure
1	10/6/98	Revised to reflect new work control process. Update group names and add new procedure numbers.
2	7/24/00	Delete HCP reference, correct grammar and minor procedural changes.
3	4/20/04	Include requirement for gas tracer study, update name of group, delete reference to HSR-5, insert HCP, insert requirements of ANSI standard, insert steps to perform tracer gas study, add forms for tracer gas.

General information, continued

Who requires training to this procedure?

The following personnel require training before implementing this procedure:

- MAQ personnel responsible for performing measurements, analysis of results, and report preparation.

Training method

The training methods for this procedure are:

- **"On-the-job"** training for technicians and staff members *performing* measurements, conducted by an individual with appropriate technical knowledge as determined and designated by the Rad-NESHAP Project Leader.
- "**Self-study**" (reading) for technicians and staff members *supporting* the measurements, analysis, and report preparation.

Training to this procedure is documented in accordance with the procedure for training (MAQ-024).

Prerequisites

In addition to training to this procedure, the following training is also required before performing measurements described in this procedure. This training is not required for personnel supporting the measurements, analysis, and report preparation.

- MAQ-Field, "General Field Safety for All Employees"
- Radiological Worker Training
- Site-specific requirements for each facility
- An "L" level security clearance is required as a minimum for some sites

Additional training may also be required depending on the configuration of the test site. The following training should be completed before a mixing test is performed:

- Basic fall protection
- Scaffold User Training
- Electrical Safety

Technicians responsible for the operation of the optical particle counters, gas detectors, and aerosol generators should refer to the owners manual for each piece of equipment for detailed operating instructions and safety precautions.

General information, continued

Definitions specific to this procedure

Aerodynamic Equivalent Diameter (D_{ae}): Diameter of a unit-density sphere having the same gravitational-settling velocity as the particle in question.

aerosol: an assembly of liquid or solid particles suspended in a gaseous medium long enough to be observed and measured; generally, about 0.001 - 100 μm in size.

Coefficient of Variation (CofV): The particle concentration standard deviation over a given area divided by the particle average concentration over the same area. May be expressed either as a fraction or a percent.

isokinetic sampling: sampling condition in which the air flowing into an inlet has the same velocity and direction as the ambient air flow.

NIST: The National Institute of Standards and Technology which provides traceable, certified calibration of many instruments and tools.

OPC: Optical Particle Counter. Most common instrument used is a MET ONE.

Tracer Gas: An inert, non-toxic, non-flammable, easily detectable gas which is injected into the air stream for the purpose of performing tracer gas studies.

References
(continued on next page)

The following documents are referenced in this procedure:
- MAQ-Field, “General Field Safety for All Employees”
- MAQ-024, “Personnel Training”
- MAQ-026, “Deficiency Reporting and Correcting”
- MAQ-035, “Work Safety Review and Authorization”
- MAQ-121, “Sampling/Monitoring Radioactive Particulates, Tritium and Gases From Exhaust Stacks, Vents, and Ducts”
- MAQ-127, “Determination of Stack Gas Velocity and Flow rate in Exhaust Stacks, Ducts, and Vents”
- MAQ-141, “Calibration and Evaluation of Pitot Tubes for Stack Flow Measurements”
- LIR 230-03-01, “Facility Management Work Control”
- LIR 402-10-01, “Hazard Analysis and Control for Facility Work”
- 40 CFR 60, Appendix A, Method 1, “Sample and Velocity Traverses for Stationary Sources”
- 40 CFR 61 Subpart H, “National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities”
- ANSI/HPS N13.1-1999, “Sampling and Monitoring Releases of Airborne Radioactive Substances From the Stacks and Ducts of Nuclear Facilities”

General information, continued

References, *continued*

- Material Safety Data Sheet (MSDS) for liquid vacuum pump oil (di-2-ethylhexyl sebacate)
- Material Safety Data Sheet (MSDS) for sulfur hexafluoride.

Note

Actions specified within this procedure, unless preceded with “should” or “may,” are to be considered mandatory guidance (i.e., “shall”).

Background information

Background information

Department of Energy facilities which have a potential to emit radioactive particulates into the environment may require sampling in accordance with 40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities." According to 40 CFR 61.93(c)(2)(ii), "The effluent stream shall be directly monitored continuously with an in-line detector or representative samples of the effluent stream shall be withdrawn continuously from the sample site following the guidance presented in ANSI/HPS N13.1-1999." All new point sources which require sampling must meet the performance requirements for single point sampling using shrouded probe technology. This sampling method is performance driven. The sampling site must meet established criteria before a single-point shrouded probe may be installed. Part of this criterion involves determining the degree of mixing, using 10 μm particles and a tracer gas, at the proposed sampling location. This procedure provides a practical approach to measure an aerosol and a tracer gas that is injected into an exhaust stack or duct so that the degree of mixing can be determined.

Performance of Work

Overview

All work performed in a facility by RRES-MAQ personnel, in support of the Rad-NESHAP Project, must be coordinated with the appropriate facility coordinators and facility management unit. All work described in this procedure will be performed in accordance with LIR 230-03-01, "Facility Management Work Control."

Facility check-in and check-out

Special check-in and check-out procedures must be followed when working in all LANL facilities. Personnel assigned to perform stack mixing studies shall ensure that all check-in and check-out procedures are followed as outlined in the facility's site-specific training.

Safety and hazard analysis

ES&H hazard screening

The **MAQ Rad-NESHAP engineer** assigned to oversee this work will ensure that all hazards are identified and mitigated according to the Integrated Work Management Process. This new process is an overlay of the existing work control process and serves the same purpose as hazard control plans and activity hazard analyses. A copy of the hazard control plan can be found as attachment 1 at the end of this procedure. If work not described in this procedure must be done, ensure the 5-step work review process and all approvals (e.g., IWDs) have been completed.

Potential hazards to consider

The following types of hazards may be present while preparing to perform the mixing study as well as during performing the work. These hazards must be identified in the appropriate integrated work document (IWD):

- potential radiation
- noise
- electricity
- rotating machinery (e.g., hand tools, pulleys, fans)
- heights (e.g., roofs, scaffolding, ladders, bucket truck)
- poor weather conditions (e.g., lightning, snow, ice, heat)
- falling objects
- compressed air
- compressed gas cylinder
- hand tools

Permits

The **RRES-MAQ engineer** ensures all permits (e.g., radiation work permits, IWD, etc.) are issued before work begins.

Radiological hazards

Before scheduling access to roof tops or opening stack measurement ports, contact facility operational personnel, area work supervisors, and local RCTs to determine if planned laboratory processes could be producing unusual radiological hazards during the stack mixing study.

Potentially contaminated equipment

Equipment used to perform the mixing study in potentially radioactive stacks must be cleared by the site radiological control technician in accordance with facility requirements and LIR 402-704-01, “Contamination Control.” If radioactive contamination is detected, trained and qualified personnel must decontaminate the unit before it may be removed from the site.

Safety and hazard analysis, continued

Personal protection equipment

Safety shoes and safety glasses must be worn while performing all airflow measurements. The following additional personal protective equipment may be required and will be indicated in the facility IWD document:

- Hard hat
- Hearing protection
- Anti-contamination clothing including rubber gloves and booties
- Respirator
- Leather gloves

Performing work safely

DO NOT perform work under conditions you consider unsafe. Before beginning work described in this procedure, review safety needs and requirements. Be aware that facility configurations and hazards may change between visits.

Equipment

Equipment and required calibrations

The following equipment is required to perform this procedure. Required calibrations and/or specifications for each piece of equipment are also listed, where applicable.

Equipment	Calibrations/Specifications
Velocity meter or pitot tube and manometer	Annual calibration of the velocity meter or manometer is required. The pitot tube must meet the dimensional requirements of 40 CFR 60, Appendix A, Test Method 2 (see MAQ-141).
Optical Particle Counters (MET ONE) **NOTE:** Two OPCs are typically needed to perform an aerosol mixing test. One OPC is used as the reference counter and the second is used as the traversing counter. If only a traversing OPC is used, the final test results are considered to be extremely conservative.	Factory calibration of the OPC must have been conducted within one year of use. The OPC must be capable of at least 1.0 actual cfm sample flow rate. The OPC must have a minimum of five sizing channels or ranges. At least one of the channels must count and size particles of 10μm ±1μm. The optical particle counters that are presently used are manufactured by MET ONE, Grants Pass, OR. **NOTE**: “MET ONE” and “OPC” are used interchangeably in this procedure.
Surrogate Aerosol	The aerosol source material must be a non-hazardous, chemically inert, relatively nonflammable, and non-radioactive substance. Presently, liquid vacuum pump oil (di-2-ethylhexyl sebacate) is used as the source material.
Aerosol Generator	The generation device must aerosolize the source material to an aerosol containing greater than 0.1% (by number) of particles over 10μm aerodynamic equivalent diameter (D_{ae}). At present, a pneumatic nozzle-type generator developed in-house is used in conjunction with a commercial air compressor to provide the surrogate aerosol that is injected into the stack or duct.

Equipment, continued

Equipment	Calibrations/Specifications
Isokinetic Sampling Probes **NOTE:** A total of two sampling nozzles are needed to accurately perform the mixing study. One probe is used as the traversing probe and the second is the reference probe. If only the traversing probe is used the final test results will be extremely conservative.	Isokinesis must be based on the average effluent velocity at the measurement point. RRES-MAQ designs the sampling probe in-house and has an outside contractor perform the fabrication. The sampling probe must be sized for slightly sub-isokinetic sampling at a flow rate of 1 acfm and be designed to minimize particle losses. When performing the tracer gas mixing study, the design of the sampling probe is less critical. Therefore, the same probes used for the aerosol study can be used to perform the gas mixing study.
Tracer Gas Detector **NOTE:** Two gas detectors are typically needed to perform a tracer gas study. One gas detector is used as the reference detector and the second is used as the traversing detector. If only a traversing gas detector is used, the final test results are considered to be extremely conservative.	Factory calibration of the tracer gas detector must have been conducted within one year of use. The gas detector must have a detection rate of at least 5 ppm with a MDL of 0.01 ppm.
Tracer Gas	The tracer gas used for the gas mixing study should be an inert, non-toxic, non-flammable, non-radioactive, easily detectable gas which is not commonly present in the effluent air stream. Currently, sulfur hexafluoride is used as the tracer gas.
Tracer gas injection probe	A tracer gas injection probe must be fabricated as specified in the ANSI/HPS standard, section 5.3. Typically, the tracer gas must be simultaneously introduced at five or more points across the cross-section of the stack or duct, unless injected before a fan.

Equipment, continued

Equipment	Calibrations/Specifications
Laptop Computer	The computer must be rugged enough for field use. It must also be able to interface with the optical particle counter and the tracer gas detector. Furthermore, the laptop must be capable of running the appropriate data acquisition and data analysis software. Alternatively, the built-in printer on the OPC can be used to capture the raw data and then manually transferred into an appropriate data analysis software (Excel).
Dry Gas Airflow Meter	The dry gas meter is used to ensure that the airflow rate of the MET ONE is in calibration and that the air pump is working properly. The calibration of the dry gas meter must be current.
PSL Particles	NIST traceable polystyrene latex (PSL) particles of at least three different diameters in the same size range expected in the surrogate aerosol.
Absolute Filter	A filter capable of filtering ambient air well enough to demonstrate zero counts.

MET One performance verification

Overview

Before the MET ONE is used to perform aerosol measurements, a performance verification test must be conducted. This test consists of checking the airflow calibration and performing a zero count purge. In addition, the factory calibration of the MET ONE must be verified at least annually. Conduct this test after the factory returns the unit from calibration and before it is used in this procedure. This calibration verification is conducted using monodisperse NIST traceable polystyrene latex (PSL) particles of at least three different diameters in the size range expected in the surrogate aerosol.

MET ONE Information

Record the MET ONE model number, serial number, and calibration expiration date on the appropriate section of the MET ONE Performance Verification Form (Attachment 2). Complete this form for each MET ONE used to perform aerosol measurements.

Airflow calibration check

Use a calibrated dry gas airflow meter to check the MET One airflow rate and verify that the air pump is working properly. Conduct this test before each use of the MET ONE.

Steps for airflow check

To conduct a MET One airflow check, perform the following steps:

Step	Action
1	Be sure you are wearing **safety shoes** and **safety glasses**.
2	Connect an airflow meter to the sensor inlet tube.
3	Turn the MET ONE ‘ON’ then press ‘OPER’. Allow several minutes for the pump and airflow to stabilize.
4	Adjust the ‘AIR FLOW’ control to its minimum and maximum flows.
5	Adjust the ‘AIR FLOW’ control until the airflow meter indicates a flow rate of 1 acfm.
6	Turn the MET ONE OFF and remove the airflow meter.
7	Record the date and results in block 2 on the MET ONE Performance Verification form (Attachment 2).

MET One performance verification, continued

Zero count purge test

This test is used to verify that particles have not contaminated the MET ONE's sensor. This test should be conducted before each use of the MET ONE. Zero counts is defined as less than 500 total counts per minute and less than 10 counts per minute of 10 µm particles.

Steps to conduct the purge test

To conduct the zero count purge test, perform the following steps:

Step	Action
1	Be sure you are wearing **safety shoes** and **safety glasses**.
2	Connect an absolute filter to the sensor inlet tube.
3	If the MET ONE 'zero-counts', as defined above, the MET ONE is functioning within specifications. Go to the *Background determination* chapter of this procedure.
4	If the MET ONE is not able to 'zero-count' within a reasonable amount of time, the sensor should be purged. To purge the sensor, allow the counter to run for 24 hours at maximum airflow with an absolute air filter in place. To save paper, select 'Disable Printer' mode.
5	If, after purging, the MET ONE is still not able to 'zero-count', there may be internal problems or the MET ONE may need to be recalibrated. Return the MET ONE to the factory for repair.
6	Record the date and results of this check in block 2 on the MET ONE Performance Verification form (Attachment 2).

Calibration verification check method

This method requires a near-isokinetic sample to be withdrawn from the chamber. The Airflow Calibration Check should be performed prior to starting this check. The PSL concentration may be kept constant so that the MET ONE total count is in the 1×10^{5} counts per minute (cpm) range. **Repeat this test three times, once for each particle size.** Allow the chamber to purge itself of aerosols between tests and clean the PSL generator with distilled water between tests.

Steps to verify calibration

To verify calibration using the wind tunnel, or dynamic environment check method, perform the following steps:

Step	Action
1	Be sure you are wearing **safety shoes** and **safety glasses**.
2	Generate aerosols using one size of the NIST traceable PSL and inject them into the test chamber.

Steps continued on next page.

MET One performance verification, continued

Step	Action
3	Insert the appropriate isokinetic sampling nozzle into the chamber and connect it to the MET ONE sensor inlet tube.
4	Set the MET ONE to sample at approximately one minute intervals obtaining at least a ten second sample.
5	Allow the PSL concentration to build so that the MET ONE total particle count is approximately 1×10^5 cpm.
6	Compute the size distribution indicated by the MET ONE for each PSL sample using the interface software for the MET ONE OPC and the laptop computer. Alternately, the MET ONE printer can be used to gather the particle counts and the data can be used to determine the PSL size distribution.
7	Verify that the calculated median particle size is counted in the correct spectrometer channel. **If the MET ONE does not perform as indicated by these tests, repeat the calibration process.** If the second calibration reveals similar results, the counter may need recalibration or repair. Refer to “Shipping Instructions” in Section 1 of the Owners Manual for information on returning the MET ONE to the factory for service.
8	Record the date and results of this check in block 3 on the MET ONE Performance Verification form (Attachment 2).
9	Complete block 4 as appropriate and sign and date the form.

Measurement Preparations

Measurement preparations

Several tasks must be performed prior to actually performing the mixing studies. These tasks include:

- Test site and equipment preparation
- Site-specific and task-specific training

Test site and equipment preparations

Several factors must first be considered before actually performing a mixing study. The following steps must be performed at the proposed test site before performing any measurements. These tasks must be a joint effort between MAQ, Facility work coordinator, and the site support contractor.

Step	Action
1	Determine the need and arrangement of scaffolding and equipment platforms. Ensure that all scaffolding and equipment platforms required are in place and meet applicable safety requirements. Equipment platforms are intended to provide support for the reference OPC/gas detector and for the traversing OPC/gas detector. Size the platforms to allow free movement over the length required to reach all traverse points and place the platform at a location that will ensure a level traverse. **NOTE:** Scaffolding construction requires a site support contractor work ticket with a facility IWD review. Scaffolding must be inspected daily by a certified safety inspector before it is used. Appropriate safety devices, as specified on the IWD, must be while working on the scaffolding.
2	Ensure that the aerosol injection point(s) are at the proper location(s) and that the holes are large enough to allow for insertion of the injecting nozzle. Use professional judgment to determine injection points. The injection points should represent a reasonable, but conservative, estimate of all potential sources so that the degree of mixing can be determined at the sampling location. Typically, one injection point in the cross section of a single duct is sufficient for aerosol testing. However, it may be necessary to have multiple injection locations to achieve the necessary amount of aerosol and tracer gas in the air stream. **NOTE:** Cutting or drilling holes in ventilation systems requires a site support contractor work ticket with a facility IWD review. A Radiation Work Permit and a Spark and Flame permit may also be required. This work is not covered by this procedure.

Steps continued on next page.

Measurement Preparations, continued

Step	Action
3	Ensure that the aerosol measurement holes are at the required location on the exhaust stack/duct and that the holes are large enough to allow insertion of the sampling probes. Round ducts will usually require two measurement holes 90^{o} apart with one traverse in the same plane as the major influent to the stack (i.e., same plane as the fan inlet to the stack). Square ducts will require multiple holes on one side, although holes may be located on adjacent sides to simplify sampling.
4	After the test site has been prepared, use procedure MAQ-127 to obtain the physical data and velocity data for the proposed testing location. Use this data, along with other relevant parameters obtained during the ventilation system walk down, to design the necessary injection and sampling probes for the mixing study.

Performing the Aerosol Mixing Study

Permits needed

The **MAQ engineer** and the local RCT will determine if a Radiation Work Permit (RWP) is necessary. HSR-1 will generate a RWP, if necessary, and ensure that all participants have read and signed the RWP before any work begins. This step is usually completed as part of the IWD process.

Steps for performing the mixing study

After all site preparations and required training has been completed, the mixing study can be performed. Typically, the aerosol mixing study is performed first then the tracer gas study is performed second. However, the sequence of the tests is not critical. Perform the following steps to perform the aerosol mixing study:

Step	Action
1	Check in with the facility coordinator or operations center before proceeding to the testing location. Verify with the facility coordinator that the ventilation system is operating under normal conditions. Proceed to the testing location.
2	Verify that the scaffolding has been inspected and has been approved for use for the current day.
3	Don all necessary PPE as outlined in the IWD.
4	Describe the measurement location in block 1 on the Measurement Location, Setup, and Results form (Attachment 3).
5	Obtain a copy of the most recent velocity profile measurement (per MAQ-127) from the MAQ engineer. Ensure that no physical changes to the ventilation system have occurred since the velocity profile measurement was performed. From the velocity measurement report, record the average measured velocity and the measurement date in block 2 on the Measurement Location, Setup, and Results form (Attachment 3). Use this velocity to verify that the selected sampling probe will provide a sub-isokinetic sampling rate at a 1 acfm to maximize the number of 10 µm particles collected. Record the sample probe serial number and internal diameter on the form.
6	Record the exhaust stack/duct dimensions in block 3 on the form. For round stacks, record the diameter. For rectangular exhaust stacks, record the width and depth (distance into the stack). Using a grease pencil, mark each sample probe with the appropriate dimensions for the required number of traverse points, as directed by the MAQ engineer. Record the number of traverse points, the spacing distances (to the nearest 1/8 inch), and the traverse directions (north-south, east-west) in block 3 on the form.

Sample probe validation

Isokinetic Velocity Verification

The sample probe selected for the aerosol mixing test must be sized to take a sub-isokinetic sample in order to maximize the number of 10 µm particles collected. Since the sample probe was selected using a recent flow measurement report, check to ensure that the current flow conditions have not changed significantly from the time that the flow measurement report was prepared.

Steps to verify isokinetic velocity

To verify isokinetic velocity, perform the following steps:

Step	Action
1	Record the measurement date in block 4 on the Measurement Location, Setup, and Results form (Attachment 2).
2	Use a calibrated velocity meter or a pitot tube and calibrated electronic digital manometer to spot check the flow rate. Choose 2 to 4 measurement points along each stack diameter and measure the velocity or velocity pressure. Record this reading in block 5 on the Measurement Location, Setup, and Results form. Determine the ratio of each measured velocity or velocity pressure with the values on the flow measurement report obtained in step 4 of the chapter *Test Site and Equipment Preparations* in this procedure. If the current velocity is not within 25% of the earlier readings, contact the MAQ Engineer for directions.

Background Determination

Background determination

Use the steps below to determine the background counts at the sample location. Samples are taken simultaneously with both MET ONEs under the control of the system computer. All pertinent information (count time, total counts, counts in each channel, etc.) will be recorded from the MET ONE to the computer. The setup and operation of the computer is not a part of this procedure.

Steps to determine background counts

To determine background counts, perform the following steps:

Step	Action
1	Place the reference and traversing MET ONE on the platforms at the sampling location. The MET ONEs should be at 90 degrees to one another.
2	Provide a means at the sampling platforms to ensure that the MET ONEs do not fall from the platforms. This may include physical tie-offs for the equipment, mechanical tracks on the platforms, mechanical locks (c-clamps) or any other reasonable means to ensure the security of the equipment.
2	Connect a calibrated dry gas meter to the sensor inlet tube of each MET ONE and adjust the AIR FLOW control to withdraw a 1 acfm sample.
3	Insert the traversing and reference sampling probes into the stack and connect them to the corresponding MET ONE. **IMPORTANT:** During the background measurements, ensure that no surrogate aerosol is injected.
4	Adjust the location of the reference MET ONE so that the sampling probe is near the stack center point. Place the traversing MET ONE so that the attached sampling probe at the first traverse point.
5	Obtain four different background measurements from both MET ONEs for a sufficient time to obtain a suitable background count (one minute samples are usually sufficient). The sample times may vary between background measurements. If the background aerosol concentration is below 10,000 total counts per minute, proceed to the chapter *Aerosol Injection*. **IMPORTANT:** Steps 6 and 7 should be completed **only** if the background appears to be > 10^4 total particle counts per minute.

Steps continued on next page.

Background Determination, continued

Step	Action
6	If the background is $>10^4$, then perform one complete traverse measurement using the traversing probe and the reference probe. Determine the coefficient of variation of the total aerosol counts for the entire data set.
7	Calculate the background average concentration plus one standard deviation for each size range. Multiply the average for each size range by 5. **This is the <u>minimum acceptable surrogate aerosol count</u>. Record this and the background CoV for each size range** in block 6 on the Measurement Location, Setup, and Results form (Attachment 3).

Aerosol injection

Aerosol injection

Use the steps below to start the aerosol injection and adjust the injection to a proper rate to ensure sufficient surrogate aerosol at the sampling point without creating coincidence counting. Perform these steps at the beginning of each new set of traverse measurements.

Steps to inject aerosol

To inject aerosol and adjust the injection rate, perform the following steps:

Step	Action
1	Ensure that all the precautions and issues outlined in the Material Safety Data Sheet (MSDS) for the liquid vacuum pump oil (di-2-ethylhexyl sebacate) have been addressed.
2	Connect the air line from the aerosol generator to a 60 psig (maximum) air supply. This may be a portable air compressor or a facility air service line.
3	Record the number of injection points and the position of the injected aerosol (distance from duct wall) in block 7 of the Measurement Location, Setup, and Results form (Attachment 3). Include a brief description of the injection probe and any other conditions which may affect the test results.
4	Insert the aerosol generator discharge tube into the stack or duct at the pre-determined injection point. Ensure that the discharge tube is located at the point in the cross section identified as the injection position and that the discharge tube is secure.
5	Start the aerosol generator.
6	Slowly adjust the aerosol generator output so that the total particle counts on the reference MET ONE is not greater than 400,000 total counts per minute. Ideally, the injection rate should be set such that the surrogate aerosol concentration at the reference MET ONE is approximately 300,000 – 320,000 total particles per minute. When the desired aerosol concentration is obtained, proceed to the next chapter *Traverse measurements of aerosol concentrations*. Slight fluctuations in the aerosol concentration are considered normal. However, if the average aerosol concentration changes by more than 25%, adjust the aerosol generator to re-establish the initial concentration. Document this adjustment in block 10 of the “Measurement Location, Setup, and Results Form” (Attachment 3).

Traverse measurements of aerosol concentrations

Traverse measurements

Perform the steps below to obtain the actual concentration measurements across each traverse. This process assumes that steps in the chapters *Background Determination* and *Aerosol Injection* have been completed and the equipment is still in position.

Steps to obtain concentration measurements

To obtain concentration measurements, perform the following steps:

Step	Action
1	Verify that the reference probe is near the center point, but clear of the path of the traversing probe.
2	Set the traversing probe to the first traverse point.
3	Using the system computer(s), sample with both the traversing MET ONE and the reference MET ONE for a sufficient time as to obtain at least the minimum acceptable surrogate count (from last step in chapter *Background Determination*). Use this same sample time for all measurements for each subsequent traverse.
4	Move the traversing probe to the next traverse point and sample again. Repeat until all traverse points have been measured along this axis.
5	Reverse the direction of movement of the traversing probe and repeat sampling at each traverse point.
6	After completing the first traverse, place the traversing MET ONE near the center point of the stack or duct. Move the reference MET ONE to the first traverse point of the second traverse: i.e., let the traversing MET ONE now be the reference MET ONE, and vise versa. Sample at all traverse points for the per-determined sampling time (from step3). For round ducts, the second traverse will be 90^{o} from the original traverse. At the completion of the second traverse this will **conclude one full set of measurement data**. For square ducts with multiple holes along one side of the duct, repeating steps 4 and 5 for each hole will conclude one full set of measurement data.
7	Repeat the full set of measurement data a minimum of 2 times.
8	If necessary as determined by the MAQ engineer, repeat steps 1 through 7 for each additional injection position. <u>**IMPORTANT:**</u> **The aerosol injection steps must also be completed for each additional injection position.**

Steps continued on next page.

Traverse measurements of aerosol concentrations, continued

Step	Action
9	After completion of the aerosol concentration profile measurements, stop aerosol generation and remove all equipment used for the aerosol mixing study. Record the computer data file name in block 8 on the Measurement Location, Setup, and Results form (Attachment 3).
10	Replace covers on all holes used during this procedure.
11	If all testing has been completed, contact the facility RCT to clear all equipment used to perform the mixing study in the potentially radioactive stack. If radioactive contamination is detected, trained and qualified personnel must decontaminate the equipment before being removed from the site.
12	Follow the site-specific procedure for check-out from the facility.

Performance of Tracer Gas Study

Overview

A tracer gas study must also be performed at the proposed sampling location, to demonstrate the location meets the requirements outlined in the ANSI/HPS N13.1-1999 standard for single point sampling. The tracer gas study is performed to demonstrate that adequate mixing is present for single point sampling using the shrouded probe technology. The results of the tracer gas study must show that the CoV of the tracer gas must be $\leq$ 20% over at least the center 2/3 of the area of the stack or duct. Furthermore, the study must also show that no point within the measurement grid has a tracer gas concentration greater than 30% of the mean concentration.

Preparing for tracer gas study

If a tracer gas study is to be performed at the proposed sampling location, the exhaust stack or duct must be configured in the same manner as previously described in the chapter *Measurement Preparations*. Furthermore, the steps outlined earlier in this procedure for getting work approved and authorized in the facility also apply and must be performed before conducting the tracer gas study. The delivery of the size 1 cylinder of tracer gas must be performed by licensed and qualified personnel. Prior arrangements must be made so that the tracer gas cylinder is delivered to the test site.

Required equipment

Collect the following equipment for the tracer gas mixing study:

- Tracer gas detector
- Size 1 Cylinder of tracer gas with associated regulators
- Tracer gas injection probe
- Tracer gas sampling probe
- Appropriate field data forms (Attachment 4 & 5)

Performing the tracer gas study

To conduct a tracer gas study, perform the following steps:

Step	Action
1	Check in with the facility coordinator or operations center before proceeding to the testing location. Verify with the facility coordinator that the ventilation system is operating under normal conditions. Proceed to the testing location.
2	Verify that the scaffolding has been inspected and has been approved for used for the current day.
3	Don all necessary PPE as outlined in the IWD.

Steps continued on next page.

Performance of Tracer Gas Study, continued

Step	Action
4	Describe the measurement location in block 1 on the Tracer Gas Measurement Location, Setup, and Results form (Attachment 4). Record the number of injection points and the injection positions (distance from duct wall) in block 6 on the Measurement Location, Setup, and Results form (Attachment 4). Include a brief description of the injection point(s) and sampling points.
5	Place the reference and traversing gas detector on the platforms at the proposed sampling location. The gas detectors should be at 90 degrees to one another. Secure the gas detectors to the platform so that they are not drop or damaged.
6	Insert the traversing and reference sampling probes into the stack and connect them to the corresponding gas detector.
7	Adjust the location of the reference gas detector so that the attached sampling probe is near the stack center point and won't interfere with the sampling probe. Place the traversing gas detector so that the attached sampling probe at the first traverse point.
8	Since the exhaust stack or duct will be exhausting primarily laboratory air, it is not necessary to perform a background test for existing tracer gases unless the tracer gas being used is commonly used in the facility as part of daily operations. If so, follow the steps outlined in the chapter *Background Determination*. Record the results in block 5 of the Tracer Gas Measurement Location, Setup, and Results form (Attachment 4).
9	Place the size 1 cylinder of tracer gas next to the tracer gas injection port. Install the appropriate regulator to the cylinder. Attach the tracer gas injection probe to one end of the tracer gas transport line and connect the other end to the discharge side of the regulator. Do not open the main valve on the tracer gas cylinder or adjust the regulator at this point.
10	Open the tracer gas injection port and insert the tracer gas injection probe into the centerline of the stack or duct. Secure the gas injection probe so that it does not move inside the stack or duct.
11	Completely open the main valve on the tracer gas cylinder. Slightly open the tracer gas regulator valve and communicate with the person at the sampling point who is monitoring the concentration of the tracer gas using the reference gas detector. Continue to open the regulator valve until a tracer gas concentration of approximately 2 parts per million is obtained. Allow several minutes for the tracer gas concentration to stabilize before proceeding to the next chapter *Traverse measurements of tracer gas concentrations*.

Traverse measurements of tracer gas concentrations

Traverse measurements

Perform the steps below to obtain the tracer gas concentration measurements across each traverse.

Steps to obtain concentration measurements

To obtain the tracer gas concentration measurements, perform the following steps:

Step	Action
1	Ensure that the tracer gas reference probe is near the center point, but clear of the path of the traversing probe.
2	Set the traversing probe to the first traverse point.
3	Monitor the readout on both gas detectors for a sufficient amount of time (30 - 60 seconds is usually sufficient) to obtain a representative sample and record the concentration on the corresponding block on the Tracer Gas Raw Data Form (Attachment 5). Record a minimum of three readings, from each detector, on the raw data form. Use this same sample time for all subsequent measurement points.
4	Move the traversing probe to the next traverse point and take a reading for the predetermined sample time until all traverse points have been measured along this axis.
5	Reverse the direction of movement of the traversing probe and repeat the sampling at all traverse points. For square ducts with multiple holes along one side of the duct, this will require inserting the traversing probe into each hole and repeating step 4.
6	After completing the first traverse, place the traversing gas detector near the center point of the stack or duct. Move the reference gas detector to the first traverse point of the second traverse. Let the traversing gas detector now be the reference gas detector, and vise versa. Repeat steps 4 and 5. At the completion of the second traverse this will **conclude one full set of measurement data**. For square ducts with multiple holes along one side of the duct, repeating steps 4 and 5 for each hole will conclude one full set of measurement data.
7	Repeat the full set of measurement data a minimum of 2 times.
8	If necessary, repeat steps 1 through 7 for each additional tracer gas injection position.

Steps continued on next page.

Traverse measurements of tracer gas concentrations, continued

Step	Action
9	After completion of the tracer gas concentration profile measurements, turn off the tracer gas injection and remove all equipment used for the tracer gas mixing study. If the data was collected electronically, record the computer data file name in block 7 on the Tracer Gas Measurement Location, Setup, and Results form (Attachment 4). Otherwise, indicate the data was manually collected on the raw data forms.
10	Replace covers on all holes used during this procedure.
11	Contact the facility RCT to clear equipment used to perform measurements in potentially radioactive stacks. If radioactive contamination is detected, trained and qualified personnel must decontaminate the equipment before being removed from the site.
12	Follow the site-specific procedure for check-out from the facility.

Final report

Report

The final report must be prepared by the individual responsible for performing the measurements or a representative as appointed by the Rad-NESHAP Project leader. The final report must outline a general overview of the testing procedure, deviations from the procedure, observations and determination of the CoV for all mixing studies as specified in the ANSI/HPS N134.1-1999 standard. An **MAQ staff member** must peer review the report before using the reported data. The final report will be submitted to the RRES-MAQ records coordinator.

Steps to prepare and submit the final report

To prepare and submit the final report, perform the following steps:

Step	Action
1	From the computer data file, calculate the mean normalized particle counts for the appropriate channels for each traverse point measured. Average each group of similar traverses and calculate the standard deviation and CoV for each group. Calculate the CoV for the entire cross-sectional area as well as the area that encompasses at least the center two-thirds of the stack or duct. Record the results in block 9 on the Measurement Location, Setup, and Results form (Attachment 3).
2	Provide comments in block 10 on the Measurement Location, Setup, and Results form, if appropriate. Record ‘None’ if there are no comments.
3	From the Tracer Gas Raw Data Input form (Attachment 5), calculate the average normalized tracer gas concentration for the three tracer gas measurements for each traverse point. Calculate the mean normalized tracer gas concentration for each traverse measured. Average each group of similar traverses and calculate the standard deviation and CoV for each group. Calculate the CoV for the entire cross-sectional area as well as the area that encompasses at least the center two-thirds of the stack or duct. Furthermore, determine if any one tracer gas concentration is higher than 30% above the mean tracer gas concentration value. Record the results in block 8 on the Tracer Gas Measurement Location, Setup, and Results Form (Attachment 4).
4	Provide comments in block 9 on the Tracer Gas Measurement Location, Setup, and Results Form, if appropriate. Record ‘None’ if there are no comments.

Steps continued on next page.

Final report, continued

Step	Action
5	Prepare a final report on the result. If necessary, attach graphs for each test series analyzed. Attach any additional analysis which may be beneficial in interpreting the test results.
6	Include the completed Aerosol Measurement Location, Setup, and Results form (Attachment 3), the completed MET ONE Performance Verification forms (Attachment 2), the Tracer Gas Measurement Location, Setup, and Results Form (Attachment 4), and Tracer Gas Raw Data Input form (Attachment 5) in the report.
7	Forward the items described in steps 1 through 6 to a technical peer reviewer as designated by the Rad-NESHAP Project Leader.

Steps to peer review the final report

To peer review the final report, perform the following steps:

Step	Action
1	Examine the report and ensure that it includes: • a completed Aerosol Measurement Location, Setup, and Results form (Attachment 3) • a completed MET ONE Performance Verification form (Attachment 2) • a completed Tracer Gas Location, Setup, and Results form (Attachment 4) • all associated graphs (attached to the Measurement Location, Setup, and Results form) • a formal write-up with a general overview of the results, deviations from the procedure, general observations, and determination of the CoV for all mixing studies as specified in the ANSI/HPS N134.1-1999 standard.
2	If any of the above items are missing, contact the author of the report and discuss the need for including the information or justification for the omission.
3	After peer review is complete and any comments resolved, submit the report to the records coordinator within 15 working days after receipt of the report.

Records resulting from this procedure

Records

MAQ personnel must submit the following records, generated as a result of performing this procedure, to the MAQ records coordinator **within 15 working days after** the report has been signed by the peer reviewer:

- the final report containing the following:
  - a completed Measurement Location, Setup, and Results form (Attachment 3)
  - a completed MET ONE Performance Verification form (Attachment 2)
  - a completed Tracer Gas Measurement Location, Setup, and Results Form (Attachment 4)
  - Tracer Gas Raw Data Input form (Attachment 5)
  - all associated graphs (attached to the Measurement Location, Setup, and Results form)
  - a formal write-up

HAZARD CONTROL PLAN

1. The work to be performed is described in this procedure:

"Measuring The Degree Of Mixing In A Stack Or Duct Using Aerosols And Tracer Gas"

2. Describe potential hazards associated with the work (use continuation page if needed).

a) Radiological hazards - Potiental contamination from contact with port plugs, probes, and other equipment that is inserted into the exhaust stack of duct. Radiological hazards may also be present from work in radiologically controlled areas.
b) hand tools - nicks, cuts, bruises from using tools.
c) Work at elevation (ladders, scaffolding, bucket truck) - slips & falls from equipment
d) General work area hazards - uneven flooring, noise, low headroom, cramped conditions
e) Facility-specific hazards - Emergency response
f) Over head work – Potential of falling objects.
g) Stack air - Workers may be exposed to pollutants in stack (rad, non-rad, chemicals) while measurement ports are open.
h) Rotating Machinery – Work may be performed in mechanical rooms and near exhaust fans.
i) Weather – Heat exposure, cold weather, wind, lighting, rain
j) Noise from mechanical equipment --When running, the wind tunnel produces some noise, but levels are well below levels that require hearing protection. Other facility areas may have hearing protection requirements.

(Continued)

3. For each hazard, list the likelihood and severity, and the resulting initial risk level (before any work controls are applied, as determined according to LIR300-00-01, section 7.2)

a) Radiological hazards - (all) frequent / negligible = Low
b) hand tools - occasional / moderate = Low
c) work at elevation (ladders, scaffolding, bucket truck) - occasional / moderate = Low
d) General work area hazards: occasional / moderate = Low
e) Facility-specific hazards: occasional / moderate = Low
f) Overhead Work - occasional / moderate = Low
g) Stack air exposure: occasional / moderate = Low
h) Rotating Machinery – occasional / moderate = Low
i) Weather – occasional / moderate = Low

Overall initial risk: ☐ **Minimal** ☒ **Low** ☐ **Medium** ☐ **High**

4. Applicable Laboratory, facility, or activity operational requirements directly related to the work:

☐ None ☒ List: Work Permits required? ☐ No ☒ List:

LIR-402-706-01 "Personnel Dosimetry"

Radiological work permit may be required for work that is performed inside the exhaust stack. Consult with facility HSR-1 team before performing the stack mixing study to ensure facility-specific radiological requirements have not changed. Other facility-specific requirements may apply for some locations. Contact FMU operations.

HAZARD CONTROL PLAN, continued

5. Describe how the hazards listed above will be mitigated (e.g., safety equipment, administrative controls, etc.):

a) Rad hazards: Rad-Worker II training, obey all postings, minimize time in any radiological area. Wear rubber gloves whenever in contact with equipment that has been inside the exhaust stack or duct. Before leaving work area, RCT must survey all equipment that was inside the stack.
b) Hand tools: work in a calm, unhurried manner. Wear leather gloves as needed.
c) Ladders/Scaffolding/Bucket Truck: Take required training (see item 6). Wear closed-toe footwear with non-slip soles when climbing ladders or scaffolding. When climbing, keep hands free of any items. Transport work items to working platform by means of a back pack or lift & lower with container and rope, as appropriate. Learn the weight limit of the scaffold & ensure it is not exceeded. When working from bucket, ensure you wear the appropriate fall protection harness and do not over-reach and keep arms inside the bucket while it is being moved.
This procedure requires two people minimum for all work in facilities.
See continuation page.

6. Knowledge, skills, abilities, and training necessary to safely perform this work (check one or both):

☒ Group-level orientation (per MAQ-032) and training to this procedure.

☒ Other → See training prerequisites on procedure page 3. Any additional describe here:

Rad Worker training. Facility-specific training.
Scaffolding Training or Ladder Safety for airflow measurements that requires the work to be performed from elevated surfaces.
For airflow measurements that require a bucket truck: training course #13079 Basic Fall Protection.

7. Any wastes and/or residual materials? (check one) ☒ None ☐ List:

PPE and HSR-1 materials (used to survey equipment for release) to be disposed of by facility personnel.

8. Considering the administrative and engineering controls to be used, the *residual* risk level (as determined according to LIR300-00-01, section 7.3.3) is (check one):

☐ Minimal ☒ Low ☐ Medium (requires approval by Division Director)

9. Emergency actions to take in event of control failures or abnormal operation (check one):

☐ None ☒ List:

For all injuries, provide first aid and see that injured person is taken to Occupation Medicine (for minor injuries and follow-up) or the hospital (if immediate medical attention is required). Notify the Operations manager of the injury. For any exposed, energized electrical wires, contact KSL or the appropriate authority to turn off the power. Follow all site specific emergency plans for any radiation or other emergencies.

Signature of preparer of this HCP: This HCP was prepared by a knowledgeable individual and reviewed in accordance with requirements in LIR 300-00-01 and LIR 300-00-02.

______________________ ______________________ ____________
Preparer(s) signature(s) Name(s) (print) /Position Date

Signature by group leader on procedure title page signifies authorization to perform work for personnel properly trained to this procedure. This authorization will be renewed annually and documented in MAQ records. Controlled copies are considered authorized. Work will be performed to controlled copies only. This plan and procedure will be revised according to MAQ-022 and distributed according to MAQ-030.

HAZARD CONTROL PLAN, continued

Hazard Control Plan continuation page. Give item number being continued.

#2) Potential Hazards:

k) Compressed Air – Size 1 compressed air cylinder, with tracer gas, will be used. Compressed air (60 psig) will also be used to operate the aerosol generator.
l) Electrical hazards – Electricity will be necessary to run laptop computer, optical particle counters, and gas detectors in outdoor environments.
m) Chemical Hazards – Sulfur Hexafluoride will be used as the tracer gas and liquid vacuum pump oil (di-2-ethylhexyl sebacate) will be used to generate the aerosol.

#3) Initial Risk Level:

j) noise from mechanical equipment -- occasional / moderate = low
k) Compresed Air – occasional/moderate = low
l) Electrical hazards – occasional/moderate = low
m) Chemical hazards - occasional/moderate = low

 # 5. How hazards are Mitigated:

d) Work area hazards: work in a calm, unhurried manner.
e) Facility-specific hazards: Have appropriate training, or be under escort by a qualified worker.
f) Overhead work: Requirements when work is being conducted at elevation (e.g., on scaffolding)

- All workers near scaffolding will wear hard hats and safety shoes when work is going on above.
- Keep all non-participants outside of the "cone of danger" by controlling access to work area.
- Secure equipment on the scaffolding or store in a container that is secured to the scaffolding.
- Workers on the ground shall remain outside the cone of danger during activities on the scaffolding or the bucket truck, unless actively assisting with hoisting or lowering.

g) Stack air: consult with HSR-1 (rad) and facility operations (non-rad & chemicals) to determine if special controls or PPE should be used during air flow measurement work
h) Rotating Machinery: Keep safe distance from moving parts. Ensure all rotating equipment have adequate guarding. If any guards are missing, stop work and report condition to facility manager.
i) Weather: Wear appropriate clothing for the climate. Wear hats, sunscreen and long sleeve shirts to avoid sunburn. Apply the 30/30 rule for situations where there is evidence of an approaching lightning storm. Do not perform measurements under high wind conditions (25 mph, sustained)
j) Noise: Use hearing protection (recommended) if working around high noise sources.
k) Compressed Air: Handle size 1 gas cylinder carefully and avoid bumping or tipping over the cylinder. Cylinder has a large amount of potential energy stored inside. Insure the proper regulators are used for the type of tracer gas used. Make sure all tubing is in good condition and fittings are tight before pressurizing the system.
l) Electrical Hazards: Use appropriately rated power cords with GFCI interrupt system when using electrical equipment in an outdoor environment.
m) Chemical hazards: Avoid inhaling the tracer gas or the surrogate aerosol. Do not use tracer gas or aerosol in a confined space. Insure there is adequate ventilation. Refer to MSDS for health hazards and recommended PPE.

Meteorology and Air Quality Group

MET ONE PERFORMANCE VERIFICATION

Page 1 of 1 This form is from RRES-MAQ-104

1. MET ONE Information:

Model: ____________________ Serial Number: ______________________

Calibration Expiration Date: ____________ LANL Number: __________________

2. Calibration Checks:

A. Airflow Calibration Check: Test Date: ____________

Airflow adjustable to 1 acfm? ☐ Yes ☐ No

B. Zero Count Purge Test: Test Date: ____________

Zero Counts? ☐ Yes ☐ No

3. MET ONE Calibration Verification: Test Date: ____________ ☐ Not Required

Particle Size: ___________ μm Total particle count: ___________ counts/min

Correct Spectrometer Channel? ☐ Yes ☐ No

Particle size: ___________ μm Total particle count: ___________ counts/min

Correct Spectrometer Channel? ☐ Yes ☐ No

Particle size: ___________ μm Total particle count: ___________ counts/min

Correct Spectrometer Channel? ☐ Yes ☐ No

4. Comments:

MET One performance verification acceptable? ☐ Yes ☐ No

Measurements by:

Signature	Print name	Z-Number	Date
____________	________________	__________	_____/_____/_____

RRES-MAQ review by:

Signature	Print name	Z-Number	Date
____________	________________	__________	_____/_____/_____

Meteorology and Air Quality Group

AEROSOL MEASUREMENT LOCATION, SETUP, AND RESULTS

Page 1 of 2

This form is from RRES-MAQ-104

TA: ___________ Building: ___________ Exhaust Stack: _________

1. Measurement Location Description:

2. Measurement Location Velocities From Flow Report: Report Date: _____________

Average Velocity (Flow Report): V_{avg} = ____________ afpm

Sample Nozzle Serial Number: __________ Internal Diameter: __________ in

3. Profile Traverse Spacing:

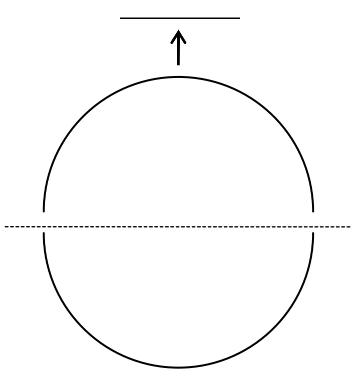
☐ Round Exhaust Stack / Duct ☐ Rectangular Exhaust Stack / Duct

Diameter: __________ in Width: __________ in

Depth: __________ in

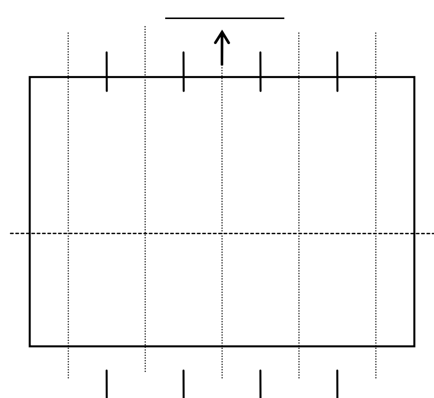
Number of Traverse Points: __________

Indicate Location of Traverse Points and Direction Below:



1

2



1 2 3 4 5

Traverse Point Distance From Inside Stack Wall (To Nearest 1/8 Inch)

1. ______	5. ______	9. ______	13. ______	17. ______	21. ______
2. ______	6. ______	10. ______	14. ______	18. ______	22. ______
3. ______	7. ______	11. ______	15. ______	19. ______	23. ______
4. ______	8. ______	12. ______	16. ______	20. ______	24. ______

Meteorology and Air Quality Group

AEROSOL MEASUREMENT LOCATION, SETUP, AND RESULTS, (continued)

Page 2 of 2 This form is from RRES-MAQ-104

4. Measurement Date:

Date: ________________

5. Isokinetic Velocity Verification:

Velocity Center Point (measured): V_{cpm} = __________ afpm

$(1 - V_{cpm} / V_{cp}) \times 100\%$ = __________ MUST BE LESS THAN 25%

6. Background Determination: Total Time: ______________ sec ☐ NA (if $\leq 10^4$)

1. Channel: 0.3 µm Total Counts: _______ CoV: _______ Avg Conc: _____
2. Channel: 0.5 µm Total Counts: _______ CoV: _______ Avg Conc: _____
3. Channel: 1.0 µm Total Counts: _______ CoV: _______ Avg Conc: _____
4. Channel: 2.0 µm Total Counts: _______ CoV: _______ Avg Conc: _____
5. Channel: 5.0 µm Total Counts: _______ CoV: _______ Avg Conc: _____
6. Channel: 10.0 µm Total Counts: _______ CoV: _______ Avg Conc: _____

7. Aerosol Injection:

Number of Injection Points: _________

Injection Positions (distance from duct wall):
1.____________________________
2.____________________________
3.____________________________

Description of Injection Points and Positions: (Attach additional sheets if necessary)

8. Data File: Data File Name: ____

9. Results:

1. Range: 0.3 - 0.5 µm O/A CofV: __________ 2/3 CofV: __________
2. Range: __________ O/A CofV: __________ 2/3 CofV: __________
3. Range: __________ O/A CofV: __________ 2/3 CofV: __________
4. Range: 5.0 - 10.0 µm O/A CofV: __________ 2/3 CofV: __________
5. Range: > 10 µm O/A CofV: __________ 2/3 CofV: __________

10. Comments:

Measurements by:

Signature	Print name	Z-Number	Date
__________	__________	__________	_____/_____/_____

MAQ review by:

Signature	Print name	Z-Number	Date
__________	__________	__________	_____/_____/_____

Meteorology and Air Quality Group

TRACER GAS MEASUREMENT LOCATION, SETUP, AND RESULTS

Page 1 of 2 This form is from RRES-MAQ-104

TA: ___________ Building: ___________ Exhaust Stack: _________

1. Measurement Location Description:

2. Measurement Location Velocities From Flow Report: Report Date: _____________

Average Velocity (Flow Report): V_{avg} = ____________ afpm

Sample Nozzle Serial Number: __________ Internal Diameter: __________ in

3. Profile Traverse Spacing:

☐ Round Exhaust Stack / Duct ☐ Rectangular Exhaust Stack / Duct

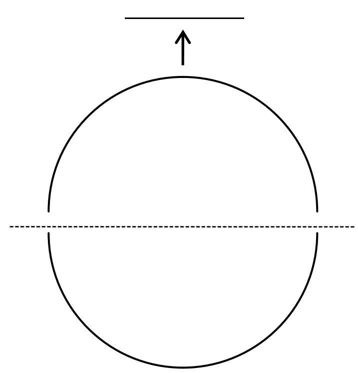
Diameter: __________ in Width: __________ in

Depth: __________ in

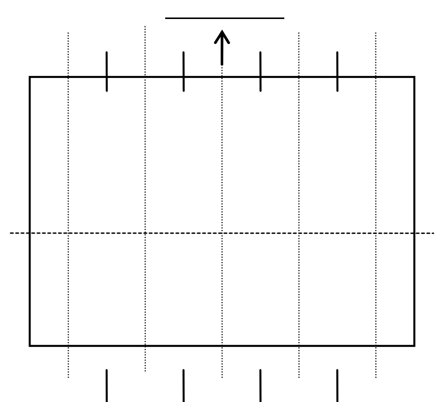
Number of Traverse Points: __________

Indicate Location of Traverse Points and Direction Below:

1



2



1 2 3 4 5

Traverse Point Distance From Inside Stack Wall (To Nearest 1/8 Inch)

1. ______	5. ______	9. ______	13. ______	17. ______	21. ______
2. ______	6. ______	10. ______	14. ______	18. ______	22. ______
3. ______	7. ______	11. ______	15. ______	19. ______	23. ______
4. ______	8. ______	12. ______	16. ______	20. ______	24. ______

Meteorology and Air Quality Group

TRACER GAS MEASUREMENT LOCATION, SETUP, AND RESULTS, (continued)

This form is from RRES-MAQ-104

4. Measurement Date: _______/_______/_______

5. Background Determination: Total Sample Time: _______ sec ☐ Not Required

Total Concentration : _______ppm Avg. Conc._______ppm CofV:___________%

6. Tracer Gas Injection:

Number of Injection Points: _________

Injection Positions (distance from duct wall): 1.____________________________

2.____________________________

3.____________________________

Description of Injection Points and Positions: (Attach additional sheets if necessary)

____

____

____

7. Attach Raw Data Sheets or Name of Data File: ____

8. Summary of Tracer Gas Tests:

Test #1: Ave.Concentration______ppm O/A CofV: __________ 2/3 CofV: __________

Test #2: Ave.Concentration______ppm O/A CofV: __________ 2/3 CofV: __________

Test #3: Ave.Concentration______ppm O/A CofV: __________ 2/3 CofV: __________

Test #4: Ave.Concentration______ppm O/A CofV: __________ 2/3 CofV: __________

Test #5: Ave.Concentration______ppm O/A CofV: __________ 2/3 CofV: __________

No single measurement >30% above mean concentration? ☐ Yes ☐ No

9. Comments:

Measurements by:

Signature	Print name	Z-Number	Date
________________	______________________	____________	_____/_____/_____

RRES-MAQ review by:

Signature	Print name	Z-Number	Date
________________	______________________	____________	_____/_____/_____

Meteorology and Air Quality Group

Tracer Gas Raw Data Input Form

Page 1 of 1 This form is from MAQ-104

TA/Building/ES: Measurement Traverse: Measurement Date :

_________-__________-__________ _________/___________/___________

Traverse Point	Location From Stack Wall	Traversing Probe			Average Tracer Gas Conc (ppm)	Reference Probe			Average Tracer Gas Conc (ppm)
		Tracer Gas Conc (ppm)	Tracer Gas Conc (ppm)	Tracer Gas Conc (ppm)		Tracer Gas Conc (ppm)	Tracer Gas Conc (ppm)	Tracer Gas Conc (ppm)	

Measurements by:

____________________ ____________________________ _______________ ______/______/______
Signature Print name Z-Number Date

MAQ QA check by (initials): MAQ review and approval by (initials):

Meteorology and Air Quality Group

Tracer Gas Raw Data Input Form

This form is from MAQ-104

TA/Building/ES: ________-_________-_________

Measurement Traverse:

Measurement Date : ________/__________/__________

Traverse Point	Location From Stack Wall	Traversing Probe			Average Tracer Gas Conc (ppm)	Reference Probe			Average Tracer Gas Conc (ppm)
		Tracer Gas Conc (ppm)	Tracer Gas Conc (ppm)	Tracer Gas Conc (ppm)		Tracer Gas Conc (ppm)	Tracer Gas Conc (ppm)	Tracer Gas Conc (ppm)	

Measurements by:

____________________ ____________________________ _______________ _____/_____/_____

Signature Print name Z-Number Date

MAQ QA check by (initials):

MAQ review and approval by (initials):

MET ONE PERFORMANCE VERIFICATION

1. MET ONE Information:

Model: ____________________ Serial Number: ______________________

Calibration Expiration Date: ____________ LANL Number: __________________

2. Calibration Checks:

A. Airflow Calibration Check: Test Date: ____________

Airflow adjustable to 1 acfm? ☐ Yes ☐ No

B. Zero Count Purge Test: Test Date: ____________

Zero Counts? ☐ Yes ☐ No

3. MET ONE Calibration Verification: Test Date: ____________ ☐ Not Required

Particle Size: ___________ μm Total particle count: ___________ counts/min

Correct Spectrometer Channel? ☐ Yes ☐ No

Particle size: ___________ μm Total particle count: ___________ counts/min

Correct Spectrometer Channel? ☐ Yes ☐ No

Particle size: ___________ μm Total particle count: ___________ counts/min

Correct Spectrometer Channel? ☐ Yes ☐ No

4. Comments:

MET One performance verification acceptable? ☐ Yes ☐ No

Measurements by:

____________________	___________________________	______________	_____/_____/_____
Signature	Print name	Z-Number	Date

RRES-MAQ review by:

____________________	___________________________	______________	_____/_____/_____
Signature	Print name	Z-Number	Date

Meteorology and Air Quality Group

AEROSOL MEASUREMENT LOCATION, SETUP, AND RESULTS

This form is from RRES-MAQ-104

TA: ___________ Building: ___________ Exhaust Stack: _________

1. Measurement Location Description:

. Measurement Location Velocities From Flow Report: Report Date: _____________

Average Velocity (Flow Report): V_{avg} = _____________ afpm

Sample Nozzle Serial Number: ___________ Internal Diameter: ___________ in

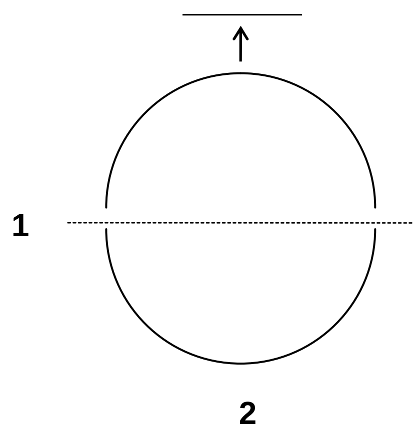
3. Profile Traverse Spacing:

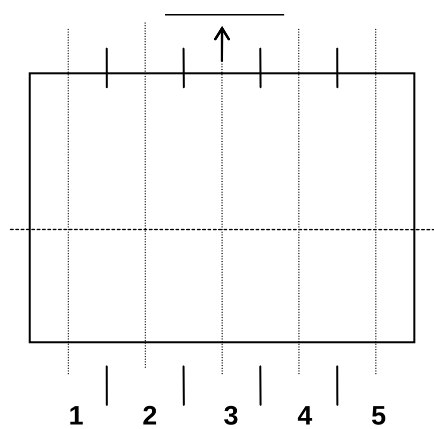
☐ Round Exhaust Stack / Duct ☐ Rectangular Exhaust Stack / Duct

Diameter: ___________ in

Width: ___________ in
Depth: ___________ in

Number of Traverse Points: ___________
Indicate Location of Traverse Points and Direction Below:





Traverse Point Distance From Inside Stack Wall (To Nearest 1/8 Inch)

1. _______	5. _______	9. _______	13. _______	17. _______	21. _______
2. _______	6. _______	10. _______	14. _______	18. _______	22. _______
3. _______	7. _______	11. _______	15. _______	19. _______	23. _______
4. _______	8. _______	12. _______	16. _______	20. _______	24. _______

AEROSOL MEASUREMENT LOCATION, SETUP, AND RESULTS
(continued)

This form is from RRES-MAQ-104

4. Measurement Date:

Date: __________________

5. Isokinetic Velocity Verification:

Velocity Center Point (measured): V_{cpm} = __________ afpm

$(1 - V_{cpm} / V_{cp}) \times 100\%$ = __________ MUST BE LESS THAN 25%

6. Background Determination: Total Time: ______________ sec ☐ NA (if $\leq 10^4$)

1. Channel: 0.3 µm Total Counts: _______ CoV: _______ Avg Conc: _____
2. Channel: 0.5 µm Total Counts: _______ CoV: _______ Avg Conc: _____
3. Channel: 1.0 µm Total Counts: _______ CoV: _______ Avg Conc: _____
4. Channel: 2.0 µm Total Counts: _______ CoV: _______ Avg Conc: _____
5. Channel: 5.0 µm Total Counts: _______ CoV: _______ Avg Conc: _____
6. Channel: 10.0 µm Total Counts: _______ CoV: _______ Avg Conc: _____

7. Aerosol Injection:

Number of Injection Points: _________
Injection Positions (distance from duct wall):
1.______________________________
2.______________________________
3.______________________________

Description of Injection Points and Positions: (Attach additional sheets if necessary)

8. Data File: Data File Name: ____

9. Results:

1. Range: 0.3 - 0.5 µm O/A CofV: __________ 2/3 CofV: __________
2. Range: __________ O/A CofV: __________ 2/3 CofV: __________
3. Range: __________ O/A CofV: __________ 2/3 CofV: __________
4. Range: 5.0 - 10.0 µm O/A CofV: __________ 2/3 CofV: __________
5. Range: > 10 µm O/A CofV: __________ 2/3 CofV: __________

10. Comments:

Measurements by:

____________________	____________________	______________	_____/_____/_____
Signature	Print name	Z-Number	Date

MAQ review by:

____________________	____________________	______________	_____/_____/_____
Signature	Print name	Z-Number	Date

Meteorology and Air Quality Group

TRACER GAS MEASUREMENT LOCATION, SETUP, AND RESULTS

 This form is from RRES-MAQ-104

TA: ___________ Building: ___________ Exhaust Stack: _________

1. Measurement Location Description:

2. Measurement Location Velocities From Flow Report: Report Date: _____________

Average Velocity (Flow Report): V_{avg} = ____________ afpm

Sample Nozzle Serial Number: __________ Internal Diameter: __________ in

3. Profile Traverse Spacing:

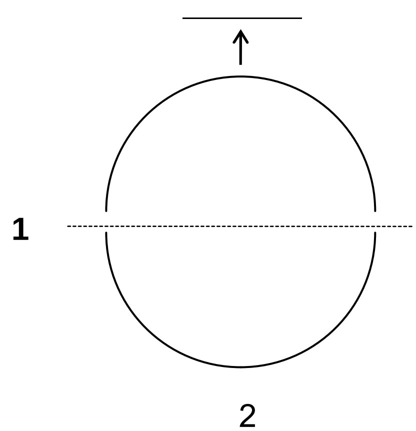
☐ Round Exhaust Stack / Duct ☐ Rectangular Exhaust Stack / Duct

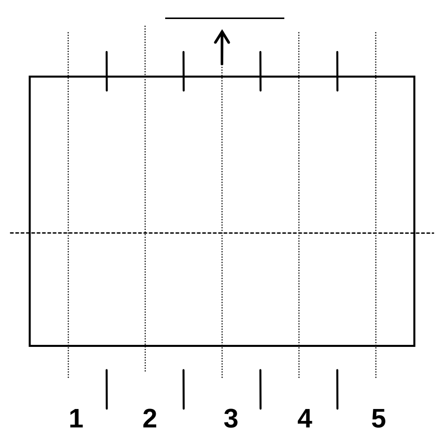
Diameter: __________ in Width: __________ in

Depth: __________ in

Number of Traverse Points: __________

Indicate Location of Traverse Points and Direction Below:





Traverse Point Distance From Inside Stack Wall (To Nearest 1/8 Inch)

1. ______	5. ______	9. ______	13. ______	17. ______	21. ______
2. ______	6. ______	10. ______	14. ______	18. ______	22. ______
3. ______	7. ______	11. ______	15. ______	19. ______	23. ______
4. ______	8. ______	12. ______	16. ______	20. ______	24. ______

TRACER GAS MEASUREMENT LOCATION, SETUP, AND RESULTS, (continued)

4. Measurement Date: _______/_______/_______

5. Background Determination: Total Sample Time: _______ sec ☐ Not Required

Total Concentration : _______ppm Avg. Conc._______ppm CofV:__________%

6. Tracer Gas Injection:

Number of Injection Points: _________

Injection Positions (distance from duct wall): 1.____________________________

2.____________________________

3.____________________________

Description of Injection Points and Positions: (Attach additional sheets if necessary)

____

____

____

7. Attach Raw Data Sheets or Name of Data File: ______________________________

8. Summary of Tracer Gas Tests:

Test #1: Ave.Concentration______ppm O/A CofV: __________ 2/3 CofV: __________

Test #2: Ave.Concentration______ppm O/A CofV: __________ 2/3 CofV: __________

Test #3: Ave.Concentration______ppm O/A CofV: __________ 2/3 CofV: __________

Test #4: Ave.Concentration______ppm O/A CofV: __________ 2/3 CofV: __________

Test #5: Ave.Concentration______ppm O/A CofV: __________ 2/3 CofV: __________

No single measurement >30% above mean concentration? ☐ Yes ☐ No

9. Comments:

Measurements by:

Signature	Print name	Z-Number	Date
__________	__________	__________	_____/_____/_____

RRES-MAQ review by:

Signature	Print name	Z-Number	Date
__________	__________	__________	_____/_____/_____